

5.20-P Using a Network of Boundary Layer Profilers to Characterize the Atmosphere at a Major Spaceport

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1. Introduction

Space launch, landing, and ground operations at the Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) in east-central Florida are highly sensitive to mesoscale weather conditions throughout the year. Due to the complex land-water interfaces and the important role of mesoscale circulations, a high-resolution network of five 915-MHz Doppler Radar Wind Profilers (DRWP) and 44 wind towers was installed over the KSC/CCAFS area. By using quality-controlled 915-MHz DRWP data along with the near-surface tower observations, the Applied Meteorology Unit and KSC Weather Office have studied the development and evolution of various mesoscale phenomena across KSC/CCAFS such as sea and land breezes, low-level jets, and frontal passages. This paper will present some examples of mesoscale phenomena that can impact space operations at KSC/CCAFS, focusing on the utility of the 915-MHz DRWP network in identifying important characteristics of sea/land breezes and low-level jets.

2. Tower and Profiler Network Characteristics

The tower network at KSC/CCAFS consists of 44 towers that measure temperature, humidity, and winds at various locations and heights ranging from 1.8 m to 150 m (Fig. A1). Most towers measure temperature at 1.8 m and winds at 16.5 m. The average tower spacing for the whole network is about 5 km. More details on the tower network are found in Case and Bauman (2004).

The Air Force operates a network of five Radian LAP[®]-3000 915-MHz DRWP at KSC/CCAFS (Lambert et al. 2003). These profilers provide high-resolution wind estimates to fill the gap between the tallest wind tower (tower #313 at 150 m height, location shown in Fig. A1) and the lowest gate of the NASA 50-MHz DRWP at 2 km. The profilers are arranged in a diamond-like pattern with an average spacing of 10–15 km (Fig. A1). They are operated with one vertical beam and two orthogonal oblique beams. The lowest gate is at 130 m and the highest is between 4–6 km, depending on instrument configuration and atmospheric conditions. The gate spacing is ~100 m and horizontal/vertical wind profile estimates are available every 15 minutes. Lambert et al. 2003 describes an automated quality-control algorithm as applied to the 915-MHz DRWP data.

3. Observations of Mesoscale Phenomena

The tower and 915-MHz profiler networks provide forecasters with a good understanding of evolving mesoscale phenomena across KSC/CCAFS. Sample tower and profiler time-height cross sections are shown for a sea-breeze (SB) and land-breeze (LB) event. The data also illustrate the profilers' ability to resolve nocturnal low-level jets that accompanied the transition of the remnant daytime SB circulation to a LB. This conference presentation will focus on a multi-day SB and LB event that occurred from 10–13 May 2000, highlighting features on 10 and 11 May.

The most distinct SB front from this event occurred on the afternoon of 10 May. Offshore flow prevailed from a west-southwesterly direction prior to the SB passage (Figs. A2a and A2b). By 1800

UTC, the SB front affected the eastern tip of CCAFS (Fig. A2c) and progressed slightly inland during the next hour (Fig. A2d). The large-scale offshore flow was weaker on the 11th, which led to an earlier onset of the SB. The wind field on 11 May included an Indian River-breeze circulation that promoted easterly flow over mainland Florida by 1600 UTC (Fig. A3a), impeding the westward progress of the SB front over the north end of the Indian River and KSC (Figs. A3b and A3c). The onshore flow behind the SB covered much of the KSC/CCAFS domain by 1900 UTC (Fig. A3d).

The low-level vertical structure of the SB frontal passage is clearly illustrated by time-height cross sections at the 150-m tall Tower #313 (Fig. A4). Just after 1900 UTC, there was an abrupt temporal gradient in the u-wind component signifying the passage of the SB front. The 2–5 m s⁻¹ southwesterly flow prior to the SB was replaced with southeasterly flow of 5–10 m s⁻¹ after the SB frontal passage. The temperature and moisture fields also exhibited marked changes across the SB front. From the surface to 150 m, the temperature decreased by as much as 2°C in 15–30 minutes with the frontal passage (Fig. A5). During the same transition period, the dew point increased from about 16°C to over 20°C (Fig. A6), resulting in a large increase in the relative humidity.

Following the daytime SB of 10 May was a “dual-surge” LB between 0200 UTC and 1000 UTC 11 May. The initial LB passage occurred at about 0315 UTC 11 May (onset of shading in Fig. A7). Southwesterly flow prevailed for several hours after the initial LB frontal passage until about 0800 UTC, when a secondary surge from the northwest overspread Tower #313. Coincident with each LB surge was a noticeable change in the low-level temperatures, particularly with the wind shift to a northwesterly direction (not shown).

The observations from the 915-MHz profiler #3 show some fascinating structure associated with the SB and LB of 10–11 May. Figures A8 and A9 depict time-height cross sections of winds and the u- and v-wind components, respectively, at profiler #3 from 1500 UTC 10 May to 1200 UTC 11 May. In Figure A8, the time of passage and depth of the SB is clearly indicated by the sharp gradients between positive/westerly u-winds (shaded regions) and negative/easterly u-winds (dashed contours without shading). Southeasterly winds associated with the SB occurred at levels up to ~600 m after 1800 UTC, and then abruptly veered to an offshore direction shortly after 0300 UTC 11 May. The shift to northwesterly winds at 0800 UTC can be seen up to 500 m (Fig. A8).

The time-height cross section of the v-wind component in Figure A9 shows a distinct wind maximum shortly after 0300 UTC, coincident with the transition from SB to LB. Between 250–750 m, a southerly low-level jet occurred for about 0.5 h, with a magnitude of nearly 20 m s⁻¹. The low-level jet exhibited both spatial and temporal continuity among the five 915-MHz profilers (not shown, but will be illustrated in the poster presentation). In addition, this feature occurred nightly from 11–13 May, but with decreasing intensity and at a slightly later time each night.

4. Summary

This paper/presentation described the utility of the combined 915-MHz profiler and tower network in resolving mesoscale phenomena that can impact space launch and shuttle landing operations at KSC/CCAFS. The 915-MHz DRWPs are particularly helpful in identifying the vertical structure of sea breezes and sometimes land breezes, as well as nocturnal low-level jets that occur above the tallest wind tower and below the first gate of the 50-MHz DRWP.

Appendix: Figures Referenced in Text

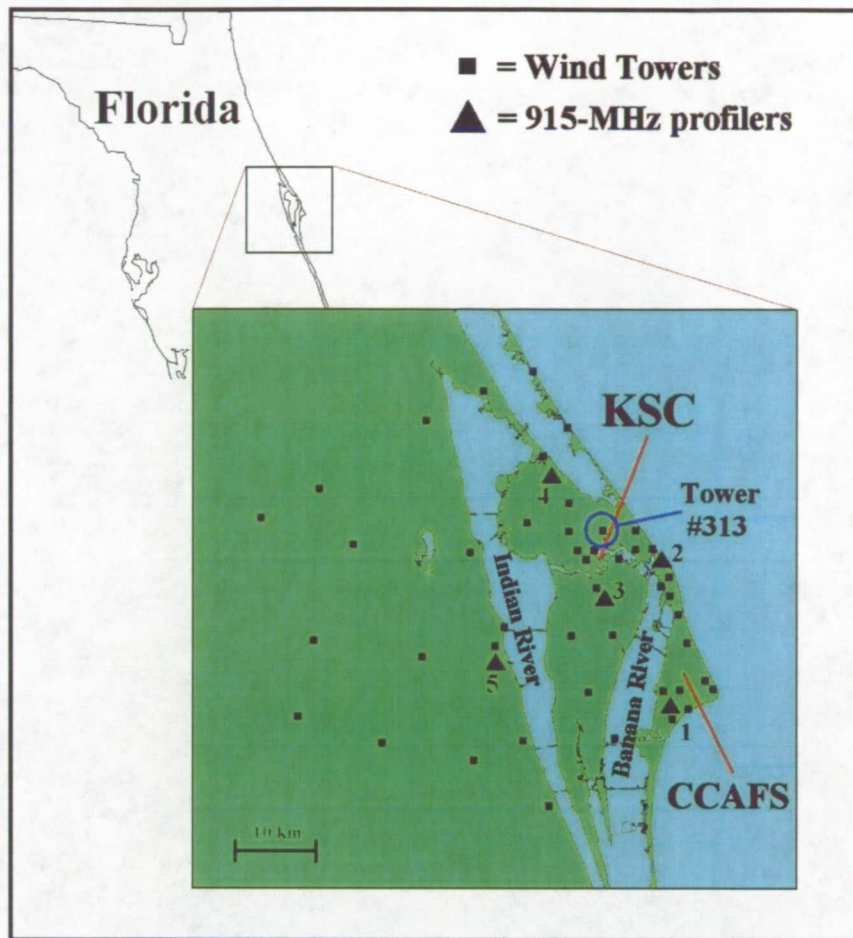
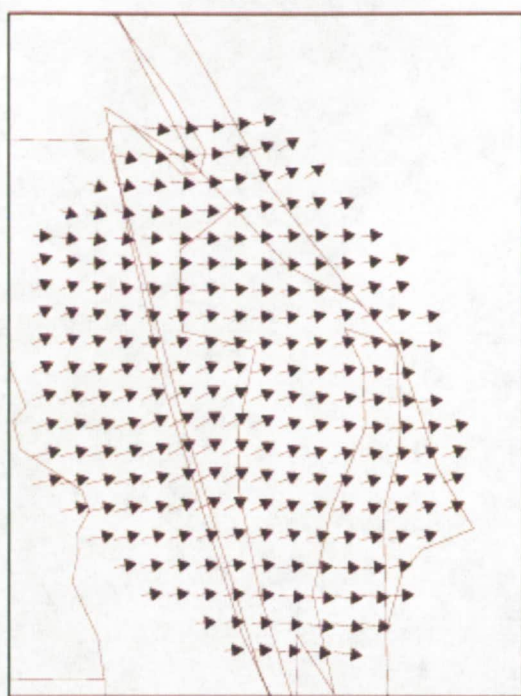
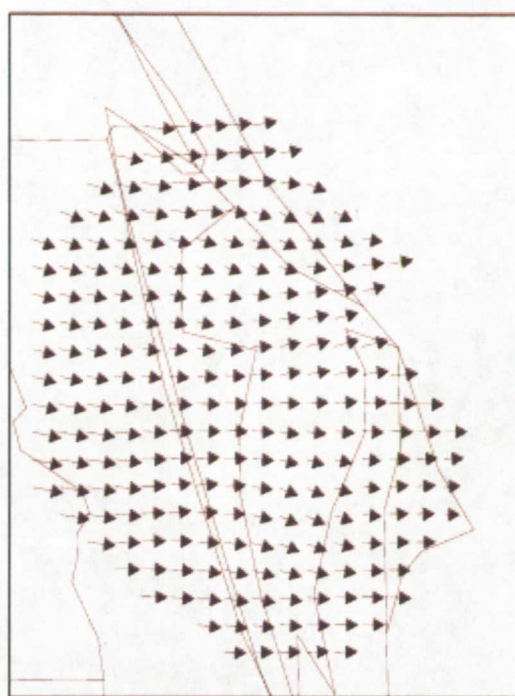


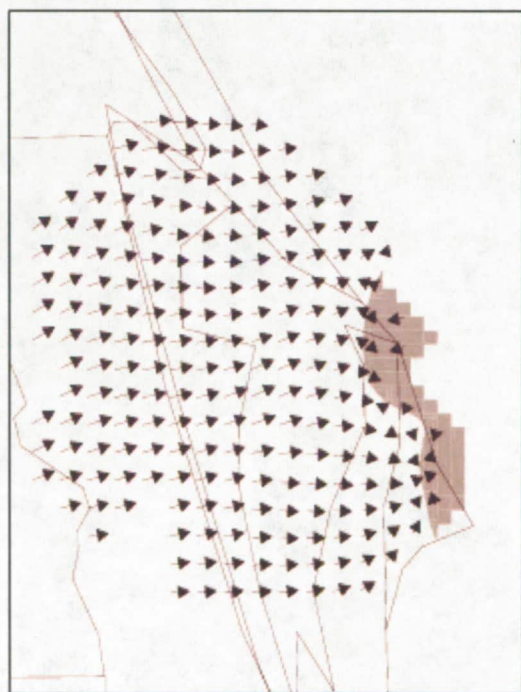
Figure A1. Locations of the 44 towers (squares) and five 915-MHz profilers (triangles) used to analyze the multi-day sea-land breeze event over east-central Florida. The locations of important geographical features and tower #313 are also indicated.



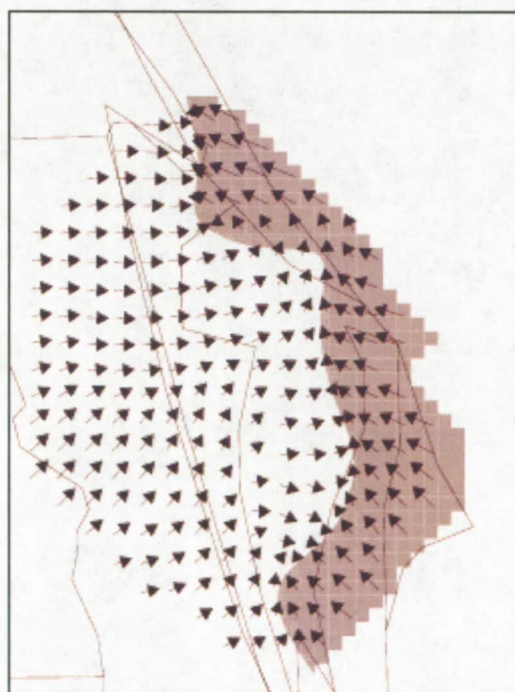
(a) Observed Winds at 1600 UTC



(b) Observed Winds at 1700 UTC

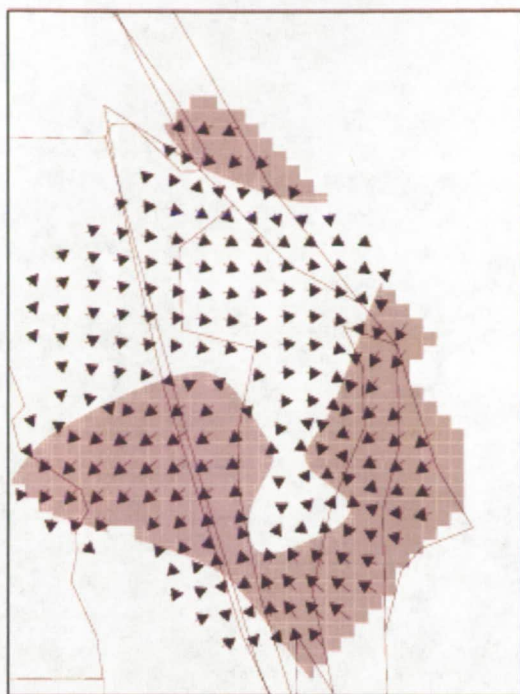


(c) Observed Winds at 1800 UTC

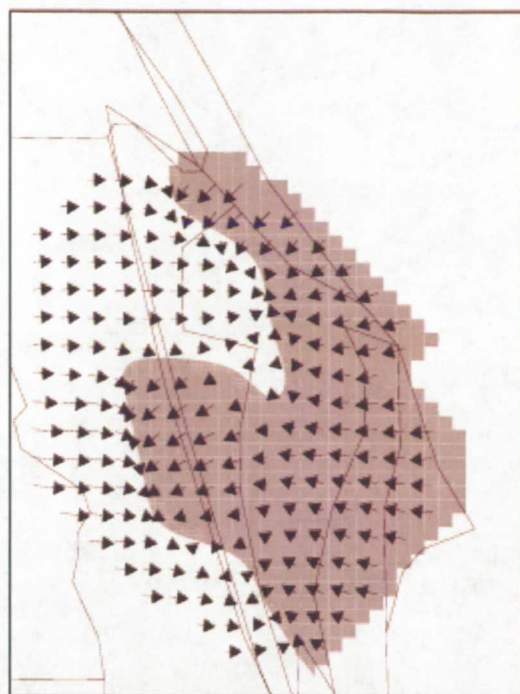


(d) Observed Winds at 1900 UTC

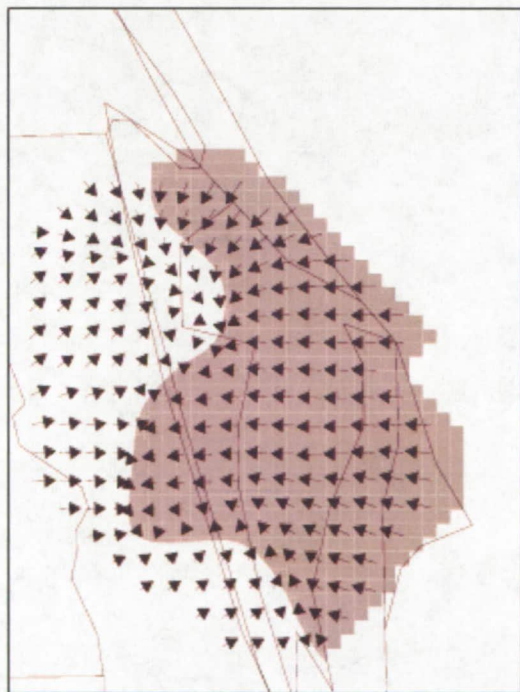
Figure A2. Grid analysis of observed KSC/CCAFS tower winds depicting the sea-breeze passage on 10 May 2000.



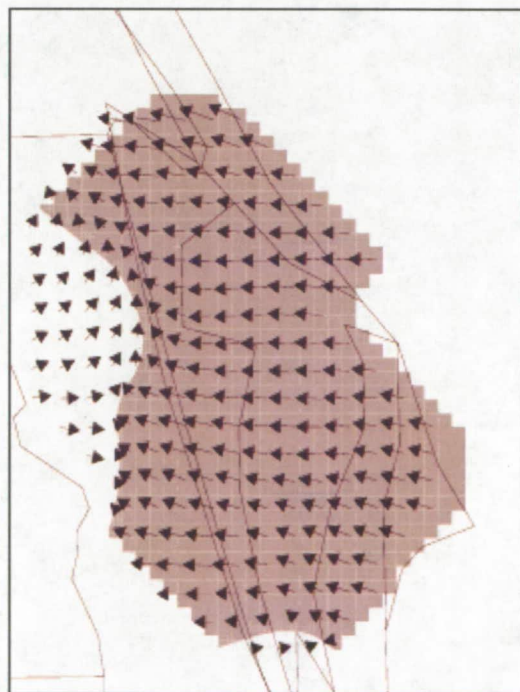
(a) Observed Winds at 1600 UTC



(b) Observed Winds at 1700 UTC



(c) Observed Winds at 1800 UTC



(d) Observed Winds at 1900 UTC

Figure A3. Grid analysis of observed KSC/CCAFS tower winds depicting the sea-breeze passage on 11 May 2000.

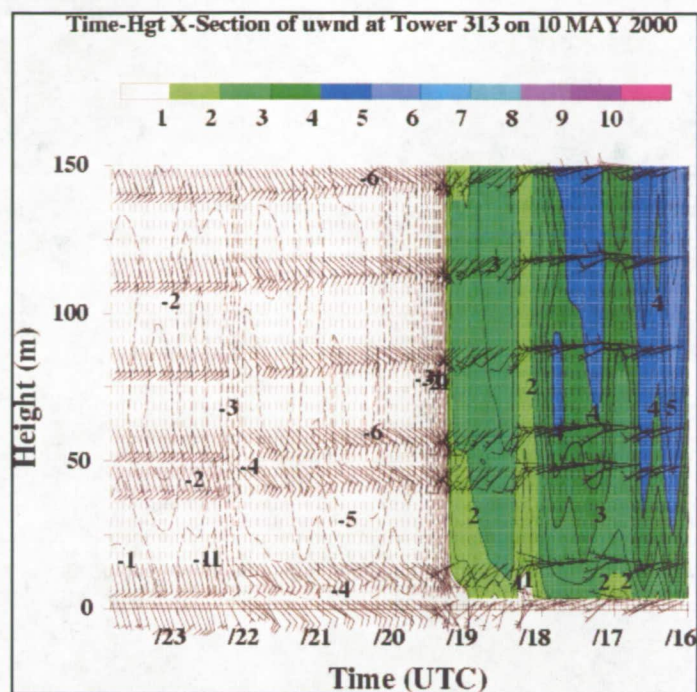


Figure A4. Time-height cross section of the u-wind component and wind barbs at tower 313 (location shown in Fig. 1) from 1600 UTC to 2355 UTC on 10 May 2000. Shading indicates positive (westerly) u-wind components in m s^{-1} given by the scale, whereas dashed contours represent negative (easterly) u-wind components.

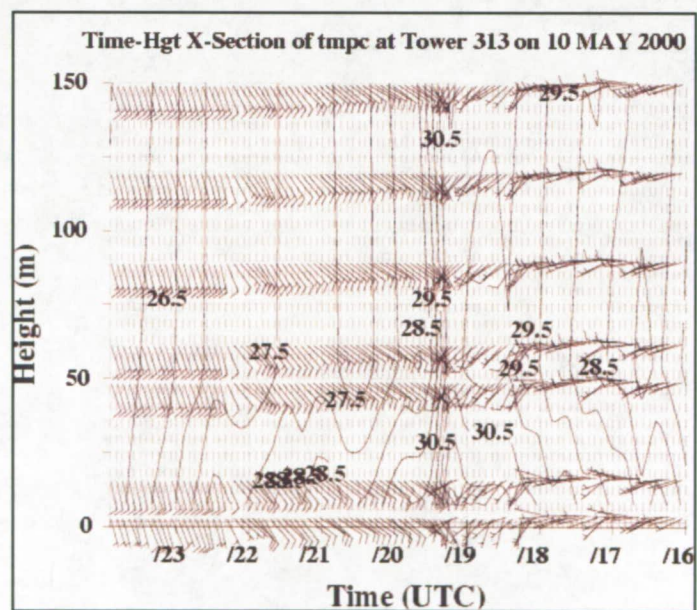


Figure A5. Time-height cross section of temperature ($^{\circ}\text{C}$) and winds at tower 313 from 1600 UTC to 2355 UTC on 10 May 2000. Temperatures are contoured every 0.5°C .

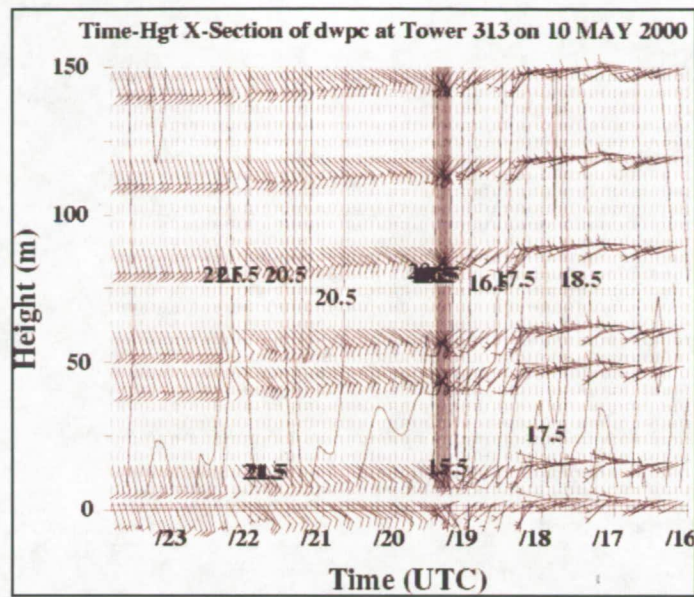


Figure A6. Time-height cross section of dew point ($^{\circ}\text{C}$) and winds at tower 313 from 1600 UTC to 2355 UTC on 10 May 2000. Dew points are contoured every 0.5°C .

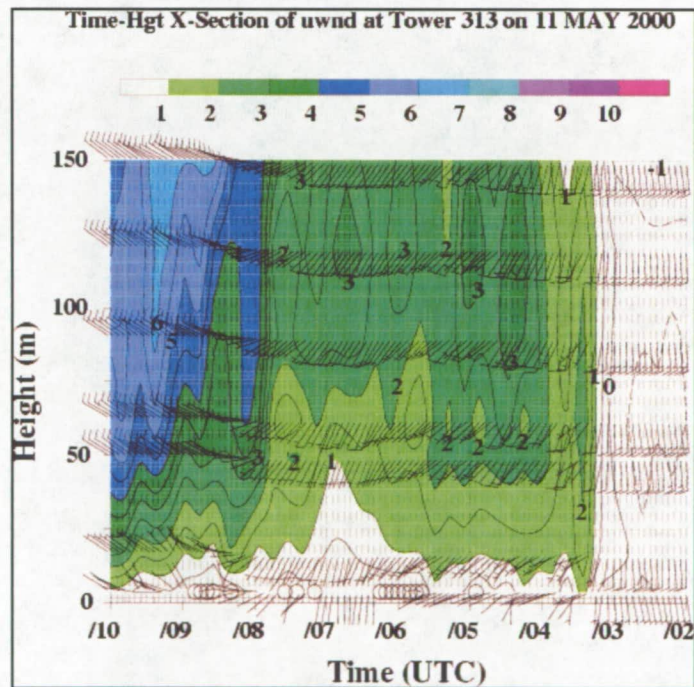


Figure A7. Time-height cross section of the u-wind component and wind barbs at tower 313 from 0200 UTC to 1000 UTC on 11 May 2000. Shading indicates positive (westerly) u-wind components in m s^{-1} given by the scale, whereas dashed contours represent negative (easterly) u-wind components.

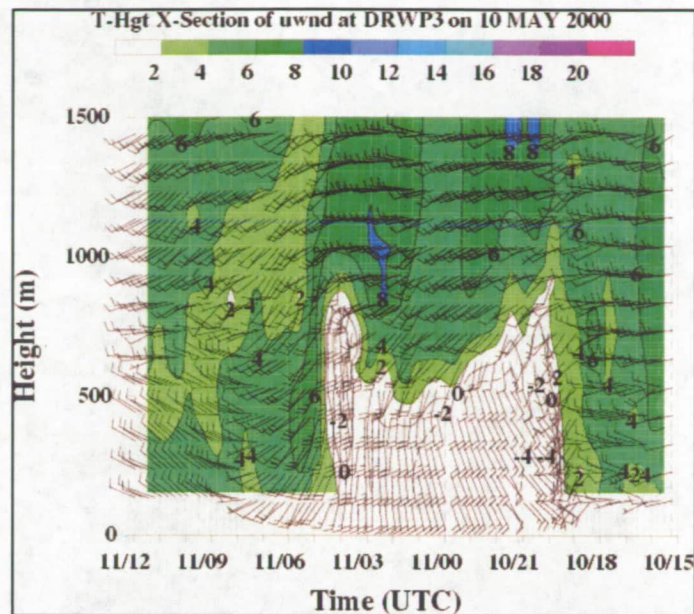


Figure A8. Time-height cross section of the u-wind component and wind barbs at 915-MHz DRWP #3 (location shown in Fig. 1) from 1500 UTC 10 May to 1200 UTC 11 May 2000. Shading indicates positive (westerly) u-wind components in m s^{-1} given by the scale, whereas dashed contours represent negative (easterly) u-wind components.

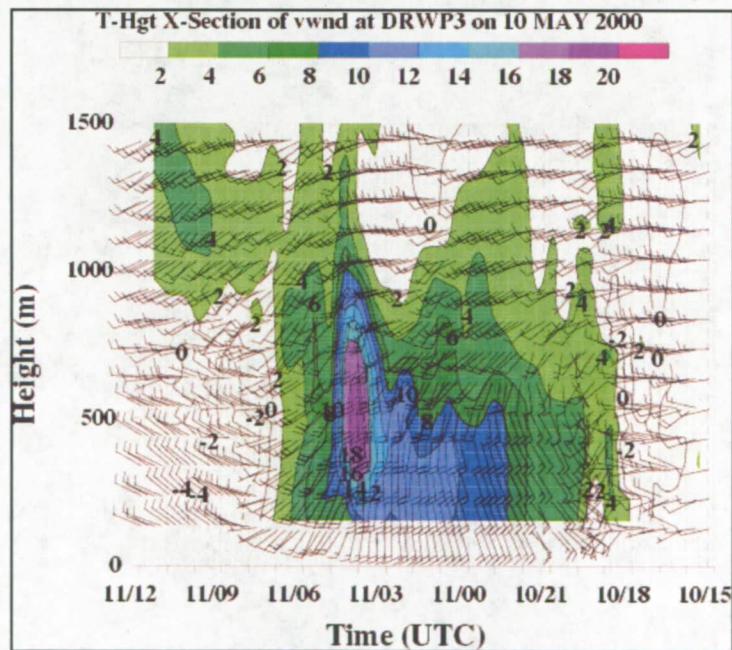


Figure A9. Time-height cross section of the v-wind component and wind barbs at 915-MHz DRWP #3 from 1500 UTC to 2300 UTC 10 May 2000. Shading indicates positive (southerly) v-wind components in m s^{-1} given by the scale, whereas dashed contours represent negative (northerly) v-wind components.

References

- Case, J. L., and W. H. Bauman III, 2004: Tower mesonetwork climatology and interactive display tool. NASA Contractor Report CR-2004-211526, Kennedy Space Center, FL, 89 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931.]
- Lambert, W. C., F. J. Merceret, G. E. Taylor, J. G. Ward, 2003: Performance of five 915-MHz wind profilers and an associated automated quality control algorithm in an operational environment. *J. Atmos. Oceanic Tech.*, **20**, 1488-1495.